

Troisième Cycle de Physique en Suisse Romande  
 Exercise for Lecture 3  
 Keith Ellis

1) Using the solutions to the massless Dirac equation given in the first lecture show that (for a massless particle)

$$\bar{u}_+(p_1)\gamma^\mu u_+(p_2) = \bar{u}_-(p_2)\gamma^\mu u_-(p_1) \quad (1)$$

Using the fierz transformation

<http://theory.fnal.gov/people/ellis/Calctools/fierz.pdf>

hence show that for a massless particle, (where  $\gamma_L = (1 - \gamma_5)/2$ ,  $\gamma_R = (1 + \gamma_5)/2$ )

$$M = \bar{s}\gamma^\mu\gamma_L c \bar{\nu}\gamma^\mu\gamma_L e \quad (2)$$

$$\equiv \bar{e}\gamma^\mu\gamma_R\nu \bar{s}\gamma^\mu\gamma_L c \quad (3)$$

$$\equiv \bar{s}\gamma_R\nu\bar{e}\gamma_L c \quad (4)$$

Hence show that the square is given by

$$|M|^2 = 8c \cdot e \cdot s \cdot \nu \quad (5)$$